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Integration of data from medical certification of cause of death and verbal autopsy

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Integration of data from medical certification of cause of death and verbal autopsy

This guidance document describes the five-step process for integrating data from medical certification of cause of death (MCCOD) for hospital deaths, and verbal autopsy (VA) data for community deaths to produce cause of death statistics for a population. For more information on interpreting the quality of mortality data from MCCOD, see *'Guidance for assessing and interpreting the quality of mortality data using ANACONDA'* available on the CRVS Knowledge Gateway here: https://crvsgateway.info/file/17068/56. For more information on interpreting VA data, see '*Guidelines for interpreting verbal autopsy data'*, available here: https://crvsgateway.info/file/18768/3231.

Introduction

Increasingly in many countries, two sets of routine cause of death data are available for policy and planning purposes:

1. Data from medical certification of cause of death (MCCOD) by physicians for hospital deaths, and;
2. Data from verbal autopsy (VA) for community (i.e., non-hospital) deaths (see **Box 1**).

Prior to the availability of data from VA, governments have commonly relied on causes of death from hospitals for their policy and planning. However, hospital deaths are typically biased towards a younger age at death and towards injuries and acute diseases. This bias has the greatest impact in countries where a large proportion of the population die outside of a hospital – which is the case for most lower- and middle-income countries (LMICs) – and where the cause of death pattern is likely to be very different.

Box 1: Defining hospital and community deaths for the integration analysis

For this analysis we classify a 'hospital death' as any death for which a MCCOD by a physician has been conducted. This includes non-hospital deaths, dead on arrival cases where the patient has been recently treated by a physician, or deaths that have been subjected to coronial enquiry, such as road traffic accidents, and where a MCCOD has subsequently been produced. A 'community death' includes all deaths that occur outside of a health facility and in a situation where it is not possible for a physician to produce a MCCOD, because the deceased did not receive treatment prior to death, or because the circumstances leading to death are not clear. In this case, a VA is the only viable alternative to produce a probable cause of death. The critical distinction is whether the death did (or could) have received a MCCOD ('hospital death') or requires a VA ('community death'). It is important that the analysis be restricted to all deaths of usual residents of the population for which the cause of death data are being compiled. This is particularly important for hospital deaths, because deaths occurring in a hospital typically include people who are not usual residents of the community served by the hospital. It is therefore important to first interrogate the hospital data to exclude non-residents of the population. Similarly, data on deaths from hospitals in other locations should be analysed and deaths of residents of your population also included in your analysis.

The policy value of the MCCOD and VA data is enhanced by integrating them to provide cause of death data for all deaths in the population. Not only does this provide countries with information on their total mortality burden, critical for effective health policy and planning, but where the data are representative of causes of death at the national level, it produces information that can be used to measure progress towards national and international goals, such as the Sustainable Development Goals (SDGs).

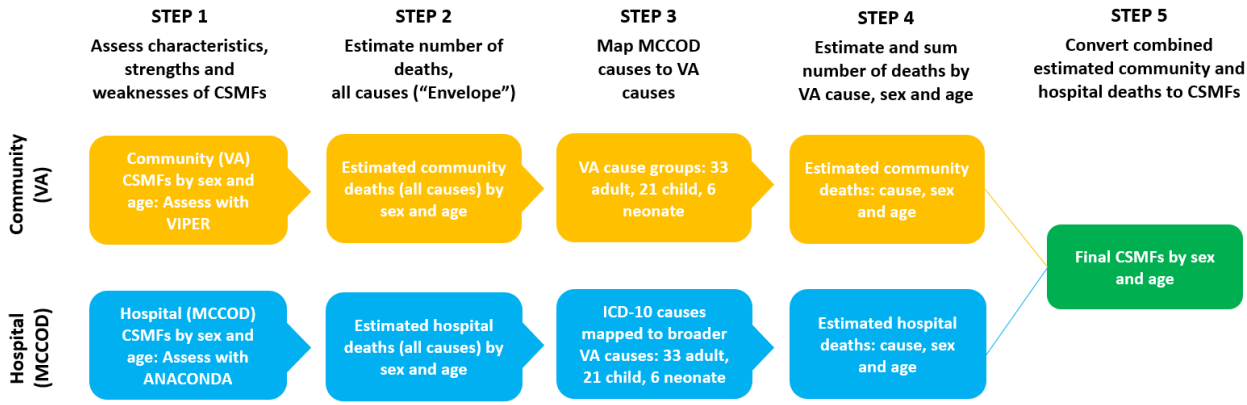
This guidance document describes the five-step process for ***integrating MCCOD data for hospital deaths and VA data for community deaths*** to produce more representative cause of death statistics for a population than either source alone would do. These combined data are likely to be useful for estimating national or sub-national cause of death patterns in a country or to monitor changes in causes of death that form the basis for assessing progress with the SDGs or other health development goals.

Overview of integration process

Integration of hospital and community cause of death data requires an accurate number of total deaths that occur in the community and in hospitals by sex and age group, otherwise integrated cause of death data will be biased. In most LMICs, however, reported (or registered) deaths, particularly in the community, are not complete. In order to produce an integrated dataset combining hospital and community deaths, we therefore need to estimate how incomplete the reported deaths are and accordingly adjust the number of reported deaths to calculate an *estimated total number of deaths (also known as the "envelope" of deaths) in the community and in hospitals*. We call these "estimates" of the number of deaths because, while they are calculated using reliable methods, incompleteness of the reported data mean that these figures have some uncertainty.[1] The process for calculating estimated deaths is described later in this document.

Both MCCOD and VA data will produce cause-specific mortality fractions (CSMFs) for each cause of death.[2] The integration of VA and MCCOD data involves taking quality-assessed CSMFs (by age and sex) from each source and multiplying it by the total number of deaths estimated to occur in the community (for VAs) and in hospitals (for MCCODs) for the respective age-sex grouping. This calculation applies the cause pattern from VAs to the estimated number of community deaths and applies the cause pattern from MCCODs to the estimated number of hospital deaths. Hospital deaths then need to be mapped from their highly specific ICD causes to the broader VA cause groups. Following this, the number of deaths by VA cause, sex and age estimated to occur in both the community and in hospital can be estimated and then summed to provide the total estimated deaths due to each cause. The combined total of estimated deaths due to each cause then needs to be divided by the combined total number of deaths to convert the data back into age and sex disaggregated CSMFs. (**Figure 1**)

Figure 1: MCCOD and VA data integration process



1 We use the term "estimated" hospital deaths here, but reported hospital deaths may be assessed as being complete and hence an estimated number of hospital deaths would not be used. See Step 2 for more details.

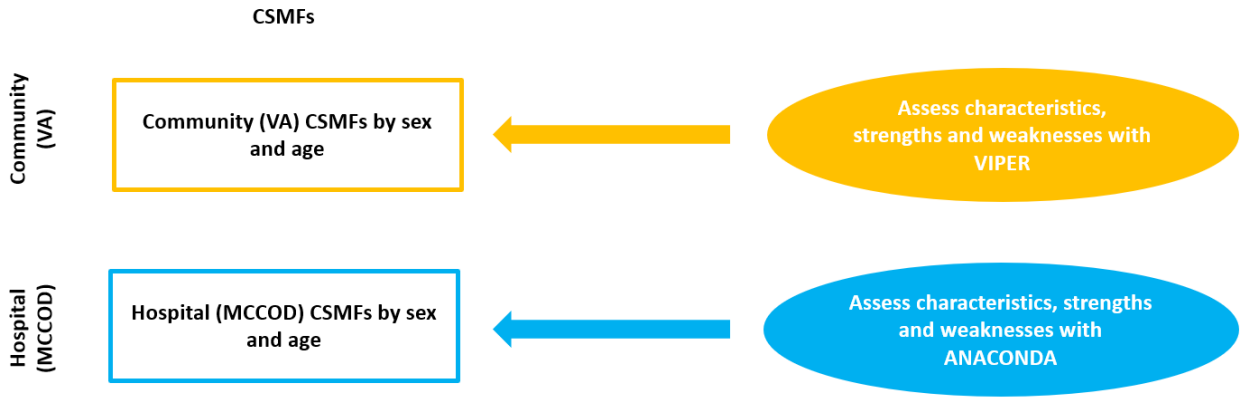
2 A CSMF is calculated as the number of deaths from a specific cause divided by total deaths in the population of interest (i.e. the community for VAs, hospitals for MCCODs)

VA and MCCOD integration steps

STEP 1: Separately assess characteristics, strengths and weaknesses of CSMFs for MCCOD and VA data

The first step involves analysing the two data sources (VA and MCCOD) separately using available tools/resources (see **Figures 1** and **2**).[3]

Figure 2: Assessment of VA and MCCOD CSMFs

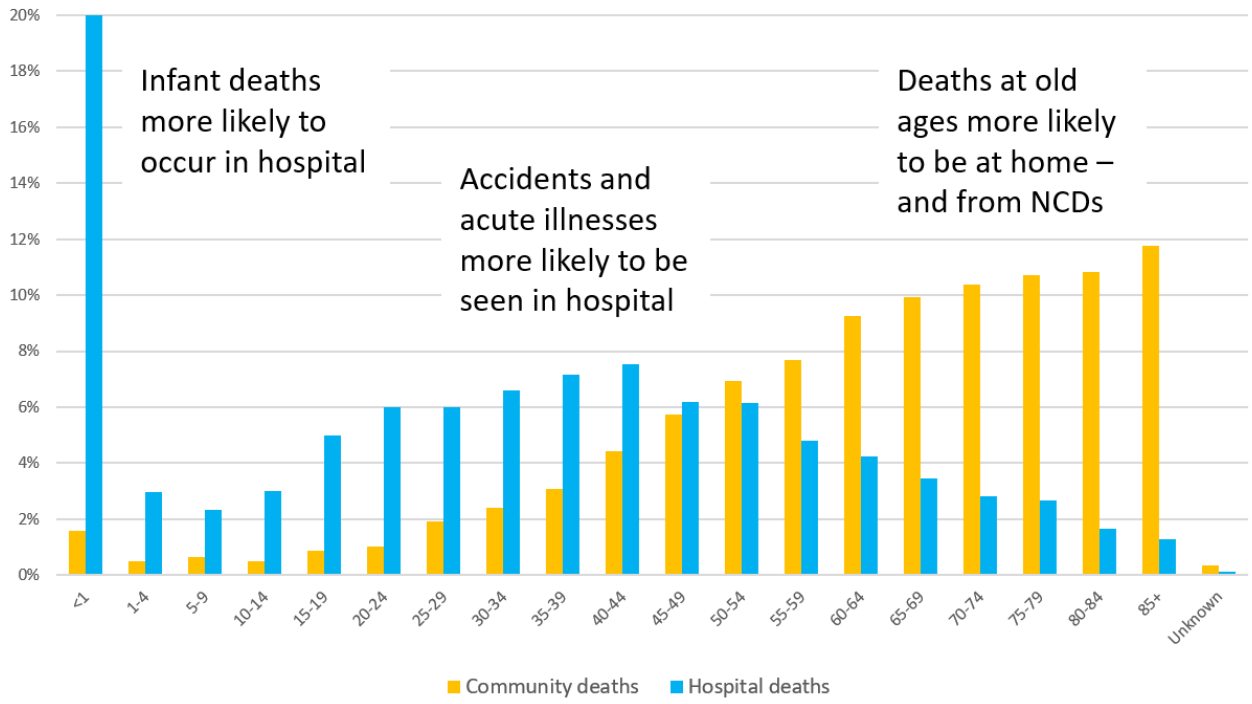


Characteristics of the datasets

The relative contribution of hospital and community deaths to the overall mortality burden, and the causes to which these deaths are assigned, will vary by age and sex. As mentioned, hospital deaths typically have a younger age-distribution than community deaths - particularly infant deaths - and tend to be biased towards acute conditions for which urgent medical treatment is sought. Deaths in the community, by contrast, more commonly occur at older ages and are more often related to non-communicable diseases (NCDs) (see **Figure 3**). These differences in the two datasets need to be understood prior to integration.

3 VIPER is available at https://crvsgateway.info/VIPER and ANACONDA is available at https://crvsgateway.info/Launching-ANACONDA~4092

Figure 3: Typical age distribution of deaths, community deaths compared to hospital



Preserving the detail in hospital cause of death

Good quality MCCOD will provide more causes and specificity than those from VA, for which only a limited set of causes of public health importance can be applied.[4] It is important to preserve this detail from MCCODs prior to integration to inform a more exact cause for hospital deaths. In addition, this information may provide insight into community causes of death that cannot be reliably predicted by VA and which fall into "residual" categories such as 'Other NCDs'.

Quality considerations for remedial action

Understanding the quality of the two data sources is important so that appropriate remedial action can be taken to improve either VA data or MCCOD. For community deaths, the Verbal Autopsy Interpretation, Performance and Evaluation Resource (VIPER)[5] can be used to help understand the plausibility of VA results and where they might differ from what is expected in terms of levels and patterns of disease. The completeness of the VA data (i.e. the fraction of community deaths eligible for a VA that are actually notified to the health centre responsible for carrying out the VA) as a percentage of community deaths is a critical element of the analysis because the cause pattern of missing community deaths may not be the same as the cause pattern of deaths that are captured through VA. The lower the completeness of VA as a percentage of community deaths, the less accurate CSMFs become.[6] At completeness levels of 50 per cent and lower, a significant bias in the community death cause pattern will likely exist, and so the integration *should not proceed*. The bias in the community death cause pattern is reduced when completeness of VA reporting is higher. Low completeness indicates the need for interventions to improve completeness of VA death reporting. Please note that the integration process requires a separate calculation of completeness of VA reporting and total estimated deaths, described in Step 2; the VIPER completeness estimate is only used to assess the *quality* of your VA data.

4 VA causes of death include 33 adult, 21 child, and six neonate causes

5 *VIPER* is available at https://crvsgateway.info/VIPER

6 Previous research has measured the impact of incomplete reporting of the fact of death on the accuracy of CSMFs. The CSMF Accuracy Metric, which ranges from 100% (completely accurate CSMFs) to 0% (completely inaccurate CSMFs), declines with lower completeness as follows: Completeness 90% = CSMF Accuracy 92.5%; Completeness 80% = CSMF Accuracy 84.1%; Completeness 70% = CSMF Accuracy 76.6%; Completeness 60% = CSMF Accuracy 66.7%; Completeness 50% = CSMF Accuracy 57.4%. Note that the overall level of CSMF accuracy is always greater than the level of completeness because deaths are typically differentially under-recorded depending on the cause of death. Ref: Phillips, D. et al (2014) A composite metric for assessing data on mortality and causes of death: the vital statistics performance index, *Population Health Metrics*, 12:14.

High levels of 'undetermined' cause of death may also indicate a problem with VA data collection. This may be remedied through improved training and supervision, or a review of data collection systems.

For hospital data, the main criteria to note before integration is the quality of the MCCOD[7]. ANAlysis of Causes of National Deaths for Action (ANACONDA)[8] can be used to understand the levels of 'unusable or insufficiently specified' causes in the ICD codes (known as "garbage codes"). ANACONDA can help to identify which chapters of the ICD these poorly coded causes are coming from, which are the most frequently used of these unusable codes, and which have the highest impact on quality of cause of death data. (**Table 1**)

Table 1: Example ANACONDA output: leading COD, with unusable (dark red) and insufficiently specified (light red) codes for COD highlighted

Rank	% of causes	ICD code	Name of category
1	11.9	I50.-	Heart failure
2	5.9	I46.-	Cardiac arrest
3	5.7	K72.-	Hepatic failure, not elsewhere classified
4	5.7	K74.-	Fibrosis and cirrhosis of liver
5	5.5	I61.-	Intracerebral haemorrhage
6	5.0	I10.-	Essential (primary) hypertension
7	2.7	R54.-	Senility
8	2.4	J96.-	Respiratory failure, not elsewhere classified
9	2.1	I74.-	Arterial embolism and thrombosis
10	2	I70.-	Atherosclerosis
11	1.8	I21.-	Acute myocardial infarction
12	1.7	R09.-	Other symptoms and signs involving the circulatory and respiratory systems
13	1.6	R73.-	Elevated blood glucose level
14	1.5	N17.-	Acute renal failure
15	1.5	J18.-	Pneumonia, organism unspecified
16	1.4	C22.-	Malignant neoplasm of liver and intrahepatic bile ducts
17	1.3	I63.-	Cerebral infarction
18	1.3	B19.-	Unspecified viral hepatitis
19	1.2	I64.-	Stroke, not specified as haemorrhage or infarction
20	1.2	N18.-	Chronic renal failure

ANACONDA outputs can be used to inform training interventions for doctors to better certify deaths and for coders to apply correct ICD codes. A high proportion of deaths in the R-Chapter (highest impact unusable codes) of the ICD (above 30 to 40 per cent) indicates poor quality data which may be biased.

Refer to the respective VIPER and ANACONDA guidelines[9] for more information on assessing the plausibility of the VA data and quality of the MCCOD data. If the data quality of one or both datasets is very poor, integration should not be attempted. Any quality issues associated with the datasets should be presented with the integration results (see *Key points and caveats* at the end of this document).

7 Completeness of death reporting as outlined in Step 2 of ANACONDA should not be applied to hospital data for which population denominators will be difficult to ascertain.

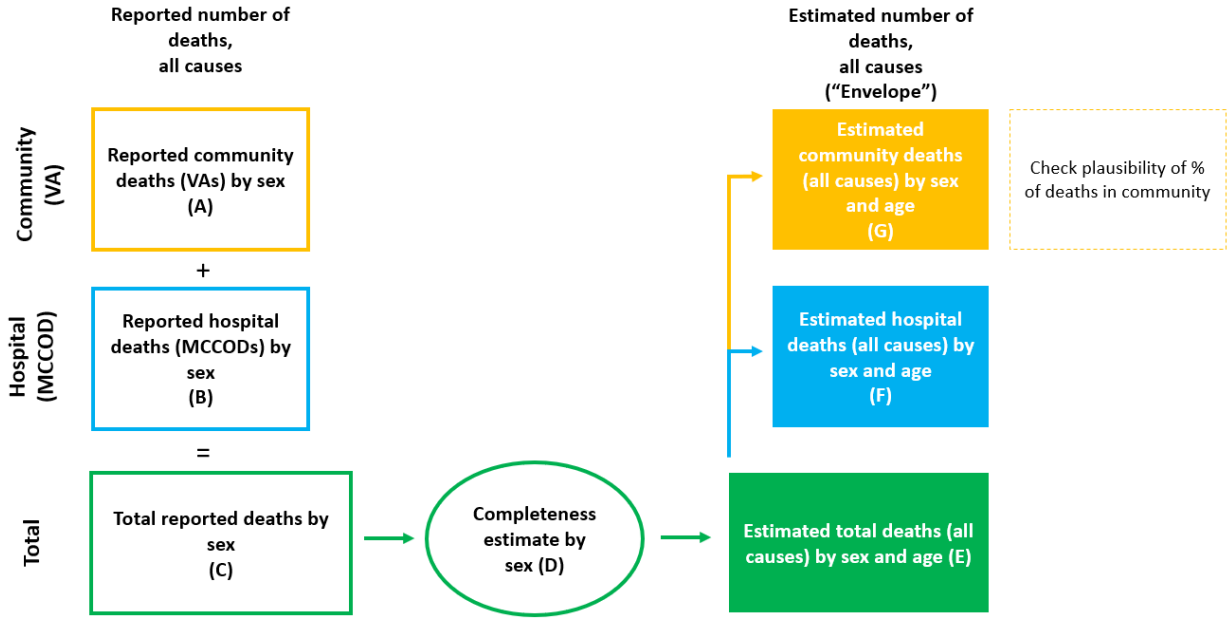
8 *ANACONDA* is available at https://crvsgateway.info/Launching-ANACONDA~4092

9 *Guidelines for interpreting VA data* is available at https://crvsgateway.info/file/17072/3231 and *Guidance for assessing and interpreting the quality of mortality data using ANACONDA* at https://crvsgateway.info/file/17068/56

STEP 2: Estimate the number of deaths that occur in the community and in hospitals

As mentioned, reported deaths in most LMICs are likely to be incomplete. Furthermore, even where VA data is collected, not all community deaths will have a VA. To integrate MCCOD and VA data, we need to calculate the number of expected deaths in the community and in hospitals.[10] The process is illustrated in **Figure 4.**

Figure 4: Process and flow for calculating estimated total, hospital and community deaths (all causes) by sex and age



Firstly, the total number of deaths for each sex in the population (hospital plus community deaths) can be estimated by applying the empirical completeness method[11] to reported deaths - VA deaths (A) plus MCCOD deaths (B). The empirical completeness method (D) estimates the completeness of the number of reported deaths (C) as a proportion of total deaths; this figure can then be used to calculate estimated total deaths in the population (E) as reported deaths divided by completeness reported as a fraction. Completeness of death reporting is likely be lower in younger than older ages. Once the total estimated deaths by sex is known, it will be necessary to estimate deaths by age group. If using the empirical completeness method, one approach to doing this is to estimate deaths at younger ages (less than 12 years) using a model life table; next, deaths at ages 12 years and above can be estimated by assuming a constant level of completeness across this age range (i.e. number of deaths divided by completeness at ages 12 years and above).[12] Alternatively, if there is an estimate of total deaths by age and sex from a reliable source such as the Global Burden of Disease[13], UN World Population Prospects[14] or national statistics office, these can be used instead. If the VA and MCCOD integration is being conducted in a population where reported deaths are complete (i.e. completeness of at least 95 per cent), then reported deaths can be used in place of estimated deaths in this step; all calculations in subsequent steps are the same.

10 In some settings, VAs will be conducted on a representative sample of reported community deaths. In this situation estimated total deaths should be calculated using reported community deaths, not the number of VAs.

11 Adair T, & Lopez, A. D. (2018). Estimating the completeness of death registration: An empirical method. PLOS ONE, 13(5), e0197047-e0197047, doi:10.1371/journal.pone.0197047.

12 More information and tailored assistance can be provided by emailing CRVS-info@unimelb.edu.au

13 Global Burden of Disease - http://ghdx.healthdata.org/gbd-results-tool

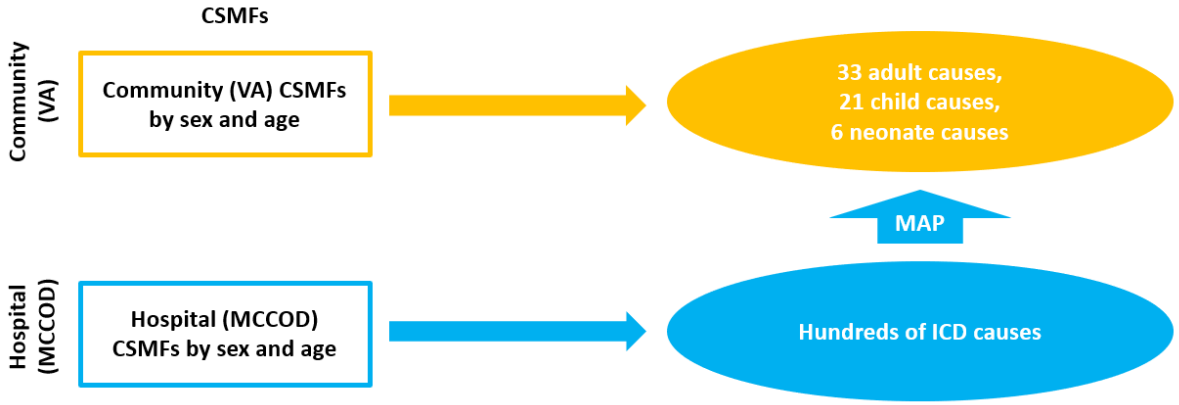
14 UN World Population Prospects - https://population.un.org/wpp/DataQuery/

Community deaths (G) can most simply be calculated as the total number of estimated deaths minus the number of reported hospital deaths (B). However, the number of reported hospital deaths may also not be complete (i.e. not all hospital deaths are reported). Therefore, after calculating community deaths it is good practice to check the plausibility of the percentage of deaths occurring in the community, which will give an indication as to whether hospital death reporting is incomplete. This plausibility check can be made against a new method being developed to estimate the percentage of deaths in a population[15] that occur in the community. Plausibility of hospital death reporting can also be based on your own knowledge of hospital and community death reporting in the population. If the number of reported hospital deaths is too low, then an estimated (adjusted) number of hospital deaths can be used instead as estimated hospital deaths (F), and then estimated community deaths re-calculated.

STEP 3: Map MCCOD causes to VA causes

For integration purposes, MCCOD data, which may include hundreds (or potentially thousands) of causes under the ICD-10, need to be mapped to the significantly smaller set of VA causes (**Figure 5**). VA causes are limited to important causes of public health importance that can be reliably predicted by VA. ICD-10 mapping to VA cause lists is available (see **Table 2**).[16]

Figure 5: Mapping of hundreds of ICD causes to VA causes for integration



15 For more information email CRVS-info@unimelb.edu.au

16 The diagram refers to SmartVA causes but could equally be applied to other VA cause-lists where mapping is available.

Table 2: SmartVA cause list mapping to ICD-10 codes for adult, child and neonate

Adult Text for Smart VA cause	ICD-10 Code
Diarrhea/Dysentery	A00-A09
TB	A15-A19
AIDS	B20-B24
Malaria	B50-B54
Other Infectious Diseases	A10-A14, A20-B19, B25-B49, B55-B99
Esophageal Cancer	C15
Stomach Cancer	C16
Colorectal Cancer	C18-C21
Lung Cancer	C34
Breast Cancer	C50
Cervical Cancer	C53
Prostate Cancer	C61
Leukemia/Lymphoma	C81-C85; C91-C96
Other Cancers	C00-C14, C17, C22-C33, C35-C49, C51-C52, C54-C60, C62-C80, C86-C90, C97-D48
Diabetes	E10-E14
Other Cardiovascular Diseases	I00-I19 I26-I59, I70-I99
Ischemic Heart Diseases	I20-I25
Stroke	I60-I69
Pneumonia	J10-J22,J85
Chronic Respiratory diseases (COPD/Asthma)	J40-J46
Cirrhosis	K70-K76
Chronic kidney disease	N17-N19
Maternal	O00-O99
Undetermined	R00-R99
Road Traffic	V01-V89
Falls	W00-W19
Drowning	W65-W74
Fires	X00-X19
Bite of Venomous Animal	X20-X29
Poisonings (accidental)	X40-X49
Suicide (intentional self-harm)	X60-X84
Homicide (assault)	X85-Y09
Other Injuries	S00-T98, V90-V99, W20-W64, W75-W99, X30-X39, X50-X59, Y10-Y98
Other Non-communicable Diseases	All other ICD-10 codes

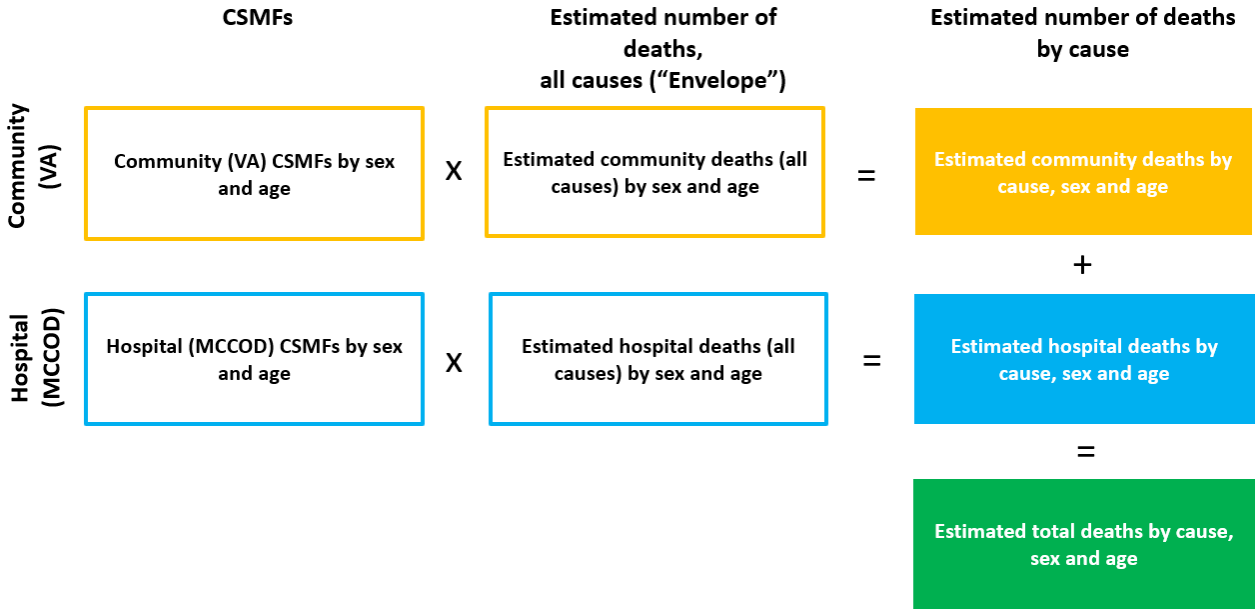
Child Text for Smart VA cause	ICD-10 Code
Diarrhea/Dysentery	A00-A09
Sepsis	A40-A41
Hemorrhagic fever	A90-A99
Measles	B05
AIDS	B20-B24
Malaria	B50-54
Other Infectious Diseases	A10-A39, A42-A91, B00- B04, B06-B49, B55-B99
Cancers	C00-D48
Meningitis	G00-G03,A39,A87
Encephalitis	G04;A83-A86
Cardiovascular Diseases	I00-I99
Pneumonia	J10-J22,J85
Digestive Diseases	K00-K93
Undetermined	R00-R99
Road Traffic	V01-V89
Falls	W00-W19
Drowning	W65-W74
Fires	X00-X19
Bite of Venomous Animal	X20-X29
Poisonings	X40-X49
Homicide	X85-Y09
Other Defined Causes of Child Deaths	All other ICD-10 codes

Neonate Text for Smart VA	ICD-10 Code
Preterm Delivery	P05-P07
Birth asphyxia	P20-P22
Pneumonia	P23-P25,J10-J22
Meningitis/Sepsis	P36, G00-G04, A39, A41, A87
Stillbirth	P95
Congenital malformation	Q00-Q99
Undetermined	All other ICD-10 codes

STEP 4: Estimate the number of deaths (by age and sex) for each cause

The CSMFs for community and hospital deaths according to the VA cause list (by age and sex) are multiplied by the estimated number of deaths in the community and hospital to obtain expected deaths by cause, age and sex for each dataset. These are summed to obtain the 'estimated total deaths by cause, sex and age'. (**Figure 6**)

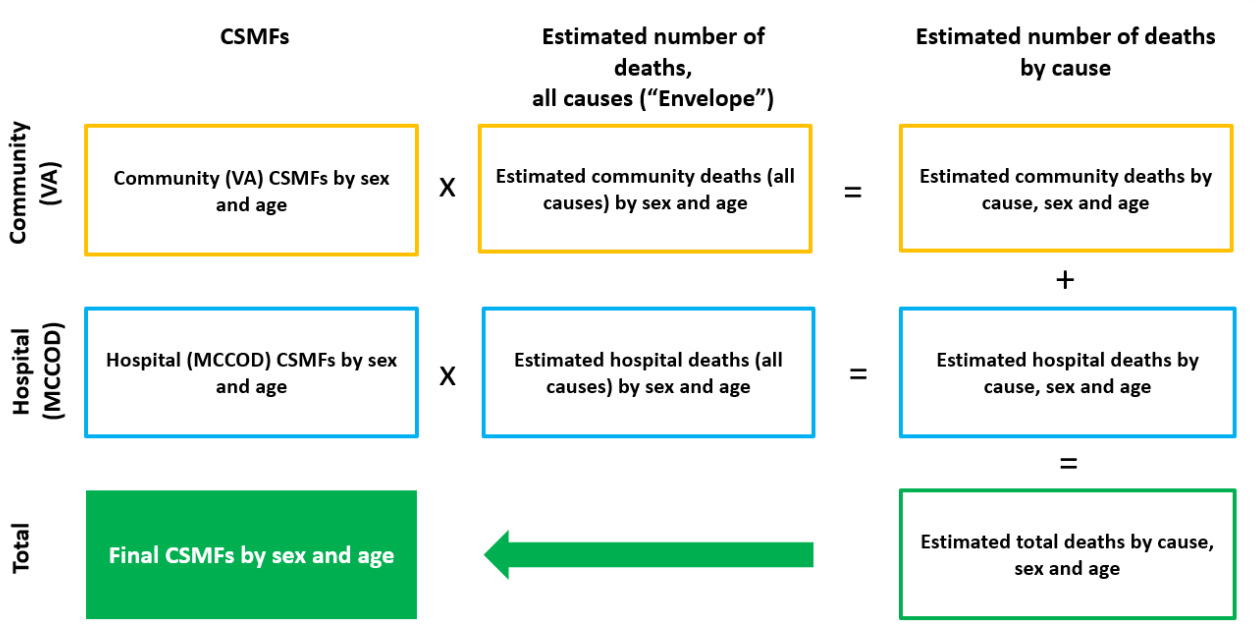
Figure 6: Process for calculating estimated deaths by cause, sex and age



STEP 5: Calculate the CSMF for all deaths (community and hospital deaths combined)

The final CSMF (for total deaths) can be calculated from the estimated total deaths by cause, sex and age, arrived at by summing community and hospital deaths by cause, sex and age (see **Figure 7**). The age specific death rate (ASDR) by cause can also be calculated for community and hospital deaths combined. The SmartVA CSMFs are provided for ages 12 years and above, so final CSMFs should also be provided for ages 12 years and above and potentially smaller age groups within this broader age group.

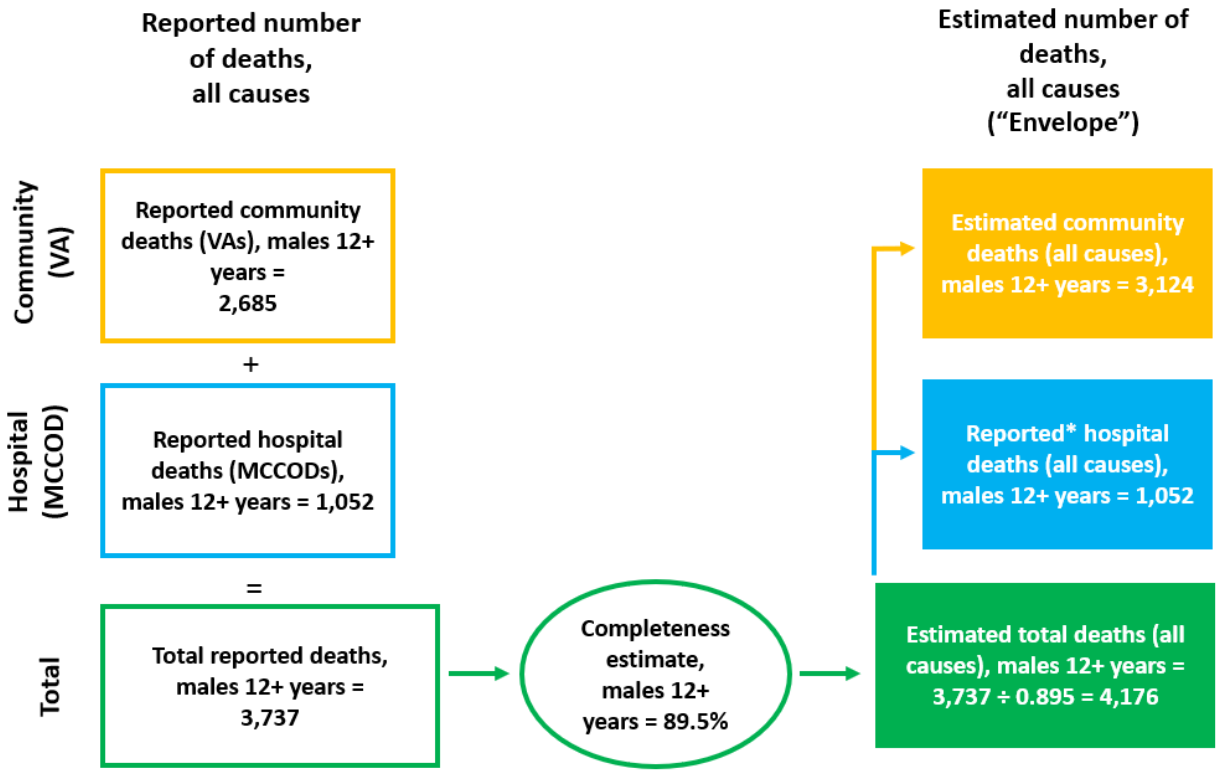
Figure 7: Calculating CSMFs (community and hospital deaths) by cause, sex and age



MCCOD and VA integration example: Lung cancer deaths, males 12+ years

Figure 8 provides an example of how to integrate MCCOD and VA deaths for lung cancer for males aged 12 years and above. Firstly, the total number of deaths need to be estimated, as per Step 2. In our example, there are 2685 reported VAs for males aged 12 years and above which are estimated to have a completeness (as a percentage of total deaths) of 64.3 per cent. This equates to 4176 total deaths for males aged 12 years and above. The estimated total deaths comprise 1052 reported hospital deaths and an estimated 3124 community deaths (the difference between estimated total deaths and reported hospital deaths). In this instance, reported hospital deaths were assessed as being complete.

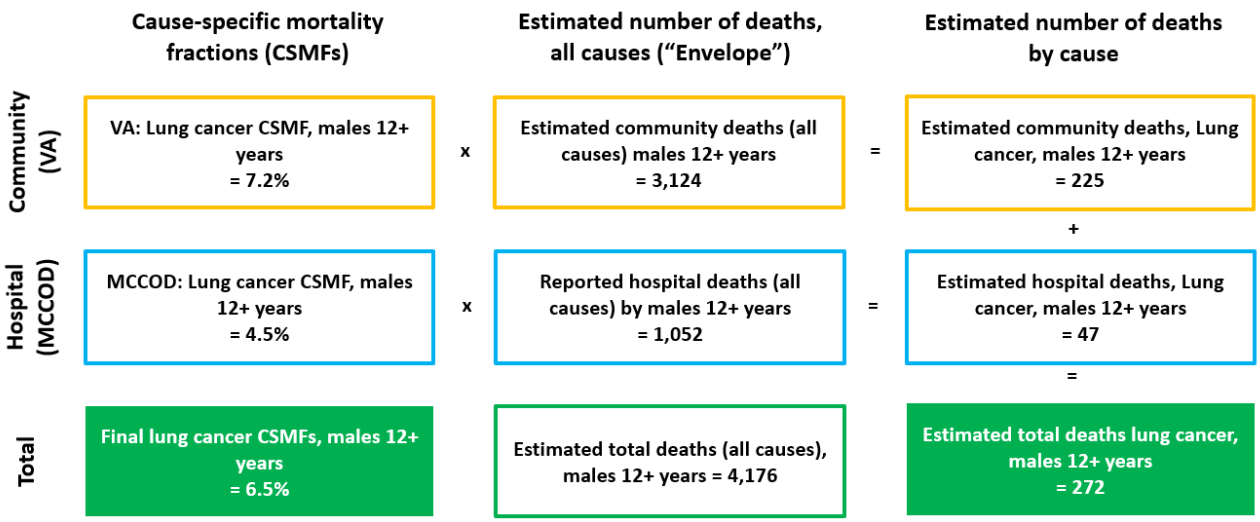
Figure 8: Calculating estimated total, hospital and community deaths in males aged 12+ (example)



*In this example, reported hospital deaths are assumed to be complete, so are the same as estimated hospital deaths.

Once we have an estimated number of total, hospital and community deaths, the integration can be completed (see **Figure 9**). The MCCOD data show a CSMF of 4.5 per cent for lung cancer for males aged 12 years and above, and the VAs show a CSMF of 7.2 per cent. This results in 47 lung cancer deaths in hospitals and 225 in the community, adding to 272 total lung cancer deaths of males aged 12 years and above. Lung cancer deaths comprise 6.5 per cent of the total 4178 deaths of males aged 12 years and above in this population.

Figure 9: Calculating estimated total deaths and CSMF due to lung cancer in males aged 12+ (example)



Key points and caveats

- Integration of MCCOD and VA data is useful to understand the total mortality burden and to measure progress towards national and international targets, such as the SDGs.
- A thorough understanding of the characteristics and quality of the two datasets should be performed prior to integration. In addition to quality:
  - The representativeness of the VA and MCCOD datasets should be assessed using VIPER and ANACONDA. If these datasets do not represent a larger (e.g., national) population (as signified by similar age-sex distribution of death, under five mortality and population aged 65 years and above), CSMF results should only be applied to the specific area for which VA and MCCOD data are derived and should not be generalised to a larger population.
- The lower the completeness of VA reporting, the more caution with which results should be interpreted:
  - The cause pattern of reported community deaths may be different to those of community deaths not reported, especially the lower the level of completeness and if unreported VAs are of poorer people living in more remoteareas. The integration should not proceed if VA deaths are estimated to be less than 50 per cent of community deaths.
  - Incomplete death reporting may result in uncertainty in the number of expected deaths in each age category. Use broad age-groups (neonatal, child, adult) to reduce this uncertainty.
- It is assumed that the collection of mortality data is part of a routine system with large datasets.
  - The uncertainty around CSMFs due to small numbers may still apply to causes with low CSMFs which should be interpreted with caution. Small numbers are particularly relevant for VA CSMFs if VAs were conducted on a sample of reported deaths. Guidance on dealing with uncertainty due to small numbers is available.17 If necessary, CSMFs should only be calculated for broader age groups (e.g. 12 years and above).
- When interpreting results, keep in mind quality issues identified in ANACONDA and VIPER, as well as potential biases in CSMFs due to low completeness of reporting. Ensure quality issues are reported with the results.
  - Combined results can be compared to GBD estimates (which represent both hospital and community deaths) as a plausibility check.

Further information

For more information and help with integration of VA and MCCOD data, email: crvs-info@unimelb.edu.au

17 *Guidelines for interpreting VA results* at https://crvsgateway.info/file/17072/3231 and *Understanding uncertainty in ANACONDA results due to small numbers of deaths: Guidance for users* at https://crvsgateway.info/file/16971/4015

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